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HENRY S. GRAVES, Forester.

FOREST PRODUCTS LABORATORY SERIES.

MECHANICAL PROPERTIES OF WOODS GROWN IN THE UNITED STATES.

PRELIMINARY SUMMARY OF TESTS ON SMALL, CLEAR, GREEN SPECIMENS OF FORTY-NINE SPECIES OF WOOD.

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TABLE 1.—*Results of tests on 49 species of wood tested in a green condition in the form of small clear pieces.*

[Test specimens are 2 by 2 inches in section. Bending specimens are cut 30 inches long; others are shorter, depending on kind of test.]

Species: Common name and botanical name.	Locality where grown.	Number of trees.	Rings per inch.	Proportion of summer wood.	Moisture content.	Specific gravity, oven dry, based on—		Shrinkage from green to oven-dry condition.			Static bending.						Impact bending.					Compression parallel to grain.			Compression perpendicular to grain, fiber stress at elastic limit.	Hardness—Load required to embed a 0.444-inch ball to one-half its diameter.			Shearing strength parallel to grain.		Cleavage strength per inch of width.		Tension perpendicular to grain.	
						Volume when green.	Volume when oven dry.	In volume.	Radial.	Tangential.	Fiber stress at elastic limit.	Modulus of rupture.	Modulus of elasticity.	Work in bending.			Fiber stress at elastic limit.	Modulus of elasticity.	Work in bending to elastic limit.	Weight of hammer.	Height of drop causing complete failure.	Fiber stress at elastic limit.	Crushing strength	Modulus of elasticity.		End surface.	Radial surface.	Tangential surface.	When surface of failure is—					
														To elastic limit.	To maximum load.	Total.												Radial.	Tangential.	Radial.	Tangential.	Radial.	Tangential.
HARDWOODS.				*Per cent.*	*Per cent.*			*Per cent.*	*Per cent.*	*Per cent.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*	*Inch lbs. per cu. in.*	*Inch lbs. per cu. in.*	*Inch lbs. per cu. in.*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*	*Inch lbs. per cu. in.*	*Pounds.*	*Inches.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*1,000 lbs. per sq. in.*	*Lbs. per sq. in.*	*Pounds.*	*Pounds.*	*Pounds.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*	*Pounds.*	*Pounds.*	*Lbs. per sq. in.*	*Lbs. per sq. in.*
Ash:																																	
Black (Fraxinus nigra)	Marathon County, Wis.		25.0		77	0.466					2,580	6,000	960	0.41	13.1	38.9	7,840	955	3.69	50	30		2,260		452	565	542	546	876	832	275	260		
White (Fraxinus Americana)	Stone County, Ark.	5	14.8	51	38	.550	0.640	12.6	4.3	6.4	5,180	9,920	1,416	1.10	20.0	43.7	11,710	1,564	4.93	50	33	3,510	4,220	1,531	889	1,121	1,000	1,017	1,360	1,312	333	346	645	671
Do	Richland Parish, La.	5	20.6	60	47	.516	.590	11.7			4,450	8,880	1,319	.87	10.6	24.0	11,720	1,388	5.55	50	32	3,210	4,040	1,497	801	842	729	734	1,239	1,166	357	341	616	611
Basswood (Tilia Americana)	Marathon County, Wis.	3	23.2	30	110	.315	.374	14.5	6.2	8.4	2,480	4,450	842	.45	5.8	8.9	5,480	917	1.84	50	16	780	1,820	1,016	197	273	226	217	560	617	130	168	226	303
Beech (Fagus atropunicea)	Hendricks and Morgan Counties, Ind.	5	16.9		61	.556	.669	16.5	4.6	10.5	4,490	8,610	1,353	.96	14.1	31.4	11,760	1,501	5.10	50	43	2,770	3,480	1,412	605	1,012	897	918	1,154	1,375	339	527	633	969
Birch, yellow (Betula lutea)	Marathon County, Wis.	5	19.7	28	72	.545	.661	17.0	7.9	9.0	4,190	8,390	1,597	.62	14.2	31.5	11,080	1,812	3.79	50	36	2,570	3,400	1,915	439	827	768	739	1,103	1,188	294	287	446	526
Elm:																																	
Rock	do		30.0		46	.578					4,290	9,430	1,222	.90	19.4	47.4	12,090	1,367	6.52	50	48		3,740		696	954	883	893	1,210	1,330	282	377		
Slippery (Ulmus pubescens)	Hendricks County, Ind.	1	8.4	68	57	.541	.639	15.5	5.1	9.9	5,560	9,510	1,314	1.32	11.7	44.2	11,700	1,569	4.86	50	40	3,410	3,990	1,453	730	919	757	687	1,197	1,174	401	424	765	832
White (Ulmus Americana)	Marathon County, Wis.		19.0		66	.430					2,850	6,940	1,052	.44	11.8	27.4	9,910	1,138	4.82	100	17		2,700		292	536	456	497	778	872	210	270		
Gum, red (Liquidambar styraciflua)	New Madrid County, Mo.	20			71	.434					3,460	6,450	1,138										2,690											
Hackberry (Celtis occidentalis)	Hendricks County, Ind.	1	8.3	70	50	.504	.576	14.0	4.2	8.9	3,320	7,800	1,170	.56	19.6	52.9	10,420	1,398	4.48	50	62	2,730	3,310	1,068	575	829	795	773	1,095	1,161	422	436	661	786
Hickory:																																	
Big shellbark (Hicoria laciniosa)	Sardis, Miss.	10	23.9	60	64	.601		17.6	7.4	11.2	6,370	11,110	1,562	1.47	24.3	78.0						3,570	4,520	1,658	994				1,134	1,191				
Do	Napoleon, Ohio	9	13.9	71	55	.666		20.9	7.9	14.2	4,800	9,880	1,099	1.23	36.2	99.0						1,820	3,260	1,257	1,000				1,094	1,330				
Bitternut (Hicoria minima)	do	11	11.7	71	65	.624					5,470	10,280	1,399	1.22	20.0	75.5						4,330	4,570	1,616	986				1,134	1,348				
Mockernut (Hicoria alba)	Sardis, Miss.	8	19.3	55	64	.606		16.5	6.9	10.4	5,900	10,840	1,625	1.22	18.6	58.2						3,600	4,600	1,681	1,065				1,165	1,375				
Do	Chester County, Pa.	11	16.6	69	57	.662		18.9	8.4	11.4	6,550	11,110	1,508	1.50	31.7	84.4						3,990	4,320	1,359	958				1,251	1,313				
Do	Webster County, W. Va.	1	31.5	61	48	.666					6,890	12,720	1,883	1.41	24.1	98.7						5,230	5,240	1,904										
Nutmeg (Hicoria myristicæformis)	Sardis, Miss.	5	22.1	58	76	.558					4,860	9,060	1,289	1.06	22.8	58.2						3,620	3,980	1,411	938				1,010	1,053				
Pignut (Hicoria glabra)	do	4	17.8	60	59	.627		15.0	5.6	9.8	6,430	11,780	1,665	1.42	24.7	65.1						3,450	4,870	1,474	1,101				1,200	1,215				
Do	Napoleon, Ohio	10	18.5	64	54	.667		15.3	6.3	9.5	6,820	12,360	1,553	1.71	27.7	88.7						4,100	4,760	1,681	1,224				1,235	1,620				
Do	Chester County, Pa.	27	18.9	67	55	.667		16.9	6.8	10.9	6,140	11,450	1,605	1.34	34.9	87.9						4,270	4,820	1,911	1,130				1,312	1,405				
Do	Webster County, W. Va.	19	22.1	63	52	.667		21.2	8.5	13.8	5,860	11,810	1,769	1.12	30.6	86.7						3,520	4,820	1,980	1,114				1,334	1,457				
Shagbark (Hicoria ovata)	Sardis, Miss.	4	20.2	62	65	.608		16.0	6.5	10.2	6,220	11,330	1,638	1.34	16.7	64.2						4,160	5,060	1,809	1,158				1,206	1,318				
Do	Napoleon, Ohio	9	17.2	71	58	.646		18.4	7.9	11.4	5,430	10,990	1,346	1.27	34.1	86.4						2,840	4,360	1,478	1,080				1,337	1,505				
Do	Chester County, Pa.	1	24.2	63	64	.617					5,900	10,170	1,392	1.61	11.9	75.3						2,780	4,370	1,029						1,245				
Do	Webster County, W. Va.	10	19.9	64	60	.653		15.5	6.5	9.7	6,120	11,000	1,752	1.22	18.3	72.3						3,730	4,600	1,943	972				1,230	1,297				
Water (Hicoria aquatica)	Sardis, Miss.	2	15.4	66	74	.630					5,980	10,740	1,563	1.29	18.8	52.9						3,240	4,660	1,926	1,088				1,390	1,490				
Locust, honey (Gleditsia triacanthos)	Hendricks County, Ind.	1	3.6	84	53	.695	.759	8.6			6,020	12,360	1,732	1.28	17.3	64.4	13,460	2,114	4.76	50	56	4,300	4,970	1,536	1,684	1,862	1,860	1,832	1,885	2,096	552	610	1,133	1,445
Maple:																																	
Red (Acer rubrum)	Marathon County, Wis.		20.0		69	.512					4,450	8,310	1,445	.78	9.8	17.1	11,670	1,411	5.45	50	28		3,680		606	766	621	626	1,130	1,330	297	330		
Sugar (Acer saccharum)	Hendricks and Morgan Counties, Ind.	5	19.0		57	.546	.643	14.3	4.9	9.1	4,630	8,860	1,462	.88	12.7	32.0	11,680	1,680	4.55	50	37	3,040	3,670	1,463	653	992	918	901	1,193	1,455	376	513	610	864
Do	Marathon County, Wis.		22.0		56	.577					4,620	8,820	1,437	.85	9.6	16.2	13,780	1,581	6.75	50	28		4,000		870	965	815	815	1,340	1,530	357	451		
Oak:																																	
Post (Quercus minor)	Stone County, Ark.	5	30.4	61	64	.590	.732	16.0	5.7	10.6	4,720	7,380	913	1.39	9.1	17.4	11,260	1,596	4.41	50	38	2,780	3,330	1,062	1,148	1,139	1,068	1,081	1,196	1,402	354	487	714	924
Red (Quercus rubra)	do	5	11.1	62	83	.569	.662	14.5	4.2	8.3	3,890	8,100	1,248	.70	12.7	40.5	10,800	1,553	4.21	50	43	2,540	3,440	1,335	844	1,139	1,044	1,039	1,215	1,226	367	446	659	880
Do	Hendricks and Morgan Counties, Ind.	6	10.7	64	80	.568	.660	13.1	3.7	8.3	3,490	7,780	1,268	.60	11.4	26.0	10,580	1,506	4.16	50	36	2,200	3,210	1,295	807	1,107	1,020	1,002	1,132	1,195	330	470	639	874
Do	Richland Parish, La.	5	10.4	70	90	.565					4,370	8,120	1,474	.75	9.8	26.4	10,250	1,803	3.30	50	40	2,670	3,460	1,924	682	924	884	901	1,047	1,059	365	410	683	787
Swamp white (Quercus platanoides)	Hendricks County, Ind.	1	15.5	71	74	.637	.792	17.7	5.5	10.6	5,380	9,860	1,593	1.05	14.5	37.6	13,280	2,048	4.79	50	50	3,470	4,360	1,489	943	1,205	1,217	1,099	1,198	1,394	428	536	757	909
Tanbark (Quercus densiflora)	Willits, Cal.				88	.585					6,580	10,710	1,678	1.49									4,840		1,355									
White (Quercus alba)	Stone County, Ark.	5	22.1	65	58	.594	.704	15.8	6.2	8.3	4,320	8,090	1,137	.95	12.1	36.7	9,860	1,414	3.84	50	40	2,400	3,520	946	829	1,113	1,030	943	1,096	1,292	382	457	622	749
Do	Hendricks, Marion, and Morgan Counties, Ind.	5	15.6	60	62	.603	.696	14.3	4.9	9.0	4,780	8,640	1,311	1.18	13.3	35.5	10,980	1,567	4.31	50	45	3,150	3,530	1,308	727	1,087	1,049	1,047	1,187	1,425	342	506	632	997
Do	Richland Parish, La.	5	16.0	67	78	.600	.708	16.0	4.8	9.2	4,410	7,760	1,194	.94	8.9	19.3	11,750	1,481	5.23	50	35	3,030	3,490	1,181	1,004	1,183	1,163	1,147	1,138	1,368	371	474	624	986
Yellow (Quercus velutina)	Stone County, Ark.	5	12.5	71	77	.573	.669	14.2	4.5	9.7	5,060	8,570	1,219	1.20	11.7	30.7	10,840	1,479	4.44	50	43	2,870	3,700	1,465	912	1,093	1,083	1,031	1,162	1,196	379	470	728	929
Do	Marathon County, Wis.		19.0		80	.550					3,720	7,650	1,121	.71	13.2	36.3	11,300	1,177	6.44	50	35		3,080		802	847	800	790	1,270	1,320	337	365		
Osage orange (Toxylon pomiferum)	Morgan County, Ind.	1	6.5	82	31	.761	.838	8.9			7,760	13,660	1,329	2.53	37.9	101.7	15,520	1,498	8.92	100	60	3,980	5,810	1,331	2,260	1,838	2,312	1,762						
Sycamore (Platanus occidentalis)	Hendricks County, Ind.	5	19.2		81	.454	.526	13.5	5.0	7.3	2,820	6,300	964	.51	7.1	13.6	8,180	1,165	3.22	50	24	2,320	2,790	1,073	433	664	560	599	900	1,102	265	425	540	781
Tupelo (Nyssa aquatica)	St. John the Baptist Parish, La.	1	15.9	26	121	.475	.545	12.4	4.4	7.9	4,300	7,380	1,045	1.00	7.8	20.9	7,650	1,310	2.49	50	25	2,280	3,550	1,280	451	814	666	733	978	1,084	277	380	472	796
CONIFERS.																																	
Arborvitæ (Thuja occidentalis)	Shawano County, Wis.	5	23.4	36	55	.293	.315	7.0	2.1	4.9	2,600	4,250	643	.60	5.7	9.5	5,290	778	2.04	50	15	1,420	1,990	754	288	321	225	228	617	614	148	139	241	235
Cedar, incense (Libocedrus decurrens)	Weed, Cal.	9	15.5		80	.363					3,950	6,040	754									2,710	3,030	868	518				613	662				
Cypress, bald (Taxodium distichum)	St. John the Baptist Parish, La.	4	24.8	38	79	.452	.513	11.5	3.8	6.0	4,430	7,110	1,378	.96	5.1	15.4	8,290	1,431	2.71	50	23	3,560	3,960	1,738	548	460	355	354	836	800	167	154	242	251
Fir:																																	
Alpine (Abies lasiocarpa)	Grand County, Colo.	5	15.0	14	47	.306	.321	9.0	2.5	7.1	2,366	4,450	861	.66	4.4	7.4	5,280	982	1.59	50	9	1,660	2,060	882	307	284	203	235	573	654	130	133		
Amabilis (Abies amabilis)	Dee, Oregon	14	7.4	34	117	.383					4,060	6,570	1,323									2,763	3,040	1,579	334				517	639				
Douglas (Pseudotsuga taxifolia)	Johnson County, Wyo.	5	17.3	22	32	.418	.458	10.9	3.7	6.6	3,570	6,340	1,242	.59	6.6	13.6	8,870	1,579	2.79	50	20	2,390	2,920	1,440	427	415	399	416	853	858	139	127		
White (Abies concolor)	Madera County, Cal.	5	9.9	30	156	.350	.437	10.2	3.4	7.0	3,880	5,970	1,131	.77	5.2	14.9	7,230	1,326	2.21	50	18	2,610	2,800	1,332	445	381	322	334	742	723	145	187	213	304
Hemlock (Tsuga canadensis)	Marathon County, Wis.	5	24.4	31	129	.340	.394	9.2	2.3	5.0	3,410	5,770	917	.73	6.6	12.9	6,330	1,025	2.19	50	17	2,110	2,750	1,054	420	463	354	334	790	813	168	151	271	323
Pine:																																	
Lodgepole (Pinus contorta)	Grand County, Colo.	5	20.1	17	44	.370	.415	11.3	4.2	7.1	3,080	5,130	1,015	.54	5.1	7.4	6,870	1,142	2.31	50	16	2,290	2,530	1,219	364	288	307	316	672	747	142	140		
Do	Johnson County, Wyo.	5	30.3	14	58	.371	.407	10.1	3.6	5.9	2,750	5,170	972	.45	5.3	11.9	6,410	1,108	2.07	50	16	1,910	2,400	991	332	316	318	319	709	719	253	200		
Longleaf (Pinus palustris)	Tangipahoa Parish, La.	5	16.5	37	63	.528	.599	12.8	6.0	7.6	5,060	8,630	1,662	.88	8.1	34.8	9,680	1,739	3.02	50	35	3,420	4,280	1,890	491	574	502	521	1,060	953	187	180	240	298
Red (Pinus resinosa)	Shawano County, Wis.	5	22.1	41	54	.440	.507	11.5	4.5	7.2	3,740	6,430	1,384	.59	5.8	28.0	7,480	1,438	2.18	50	28	2,470	3,080	1,646	358	355	345	340	812	741	161	154	179	205
Shortleaf (Pinus echinata)	Malvern, Ark.	70	13.4		52	.477					4,360	7,710	1,395										3,570		400				746	670				
Sugar (Pinus lambertiana)	Madera County, Cal.	5	11.9	34	123	.360	.386	8.4	2.9	5.6	3,330	5,270	966	.66	5.0	11.6	6,740	1,083	2.34	50	17	2,340	2,600	1,029	353	334	307	342	702	714	168	189	239	304
Western yellow (Pinus ponderosa)	Coconino County, Ariz.	5	21.4	26	98	.353	.395	9.2	4.1	6.4	2,660	4,760	879	.47	4.9	12.4	6,160	979	2.13	50	17	1,900	2,220	1,046	342	310	311	318	644	680	152	179	281	321
Do	Madera County, Cal.	5	13.0	31	125	.377	.433	11.5	4.3	7.3	3,180	5,180	1,111	.52	4.3	15.6	7,070	1,115	2.51	50	21	2,100	2,420	1,271	326	316	306	323	686	706	162	187	230	252
Do	Douglas County, Colo.	5	31.9	20	93	.391	.435	9.9	3.8	5.8	3,310	5,460	1,053	.59	6.0	12.0	6,910	1,203	2.20	50	20	2,250	2,600	1,174	410	315	330	332	694	717	152	154		
White (Pinus strobus)	Shawano County, Wis.	5	16.2	31	74	.363	.391	7.8	2.2	5.9	3,410	5,310	1,073	.62	5.9	13.3	6,490	1,156	2.06	50	18	2,370	2,720	1,318	314	304	294	299	649	639	144	160	225	285
Redwood (Sequoia sempervirens)	Humboldt County, Cal.		14.5	24	81	.334					4,530	6,560	1,024									3,420	3,820	1,175	539									
Do	Mendocino County, Cal.		24.4	32	69	.366					5,020	7,460	1,101									3,560	4,160	1,272	618									
Spruce:																																	
Engelmann (Picea engelmanni)	Grand County, Colo.	5	17.1	16	45	.325	.359	10.5	3.7	6.9	2,740	4,550	866	.50	4.8	6.1	6,300	1,076	2.09	50	13	1,880	2,170	1,021	302	272	253	274	607	624	110	135		
Do	San Miguel County, Colo.	5	11.3	13	156	.299	.335	10.3	3.0	6.2	2,180	3,850	798	.36	5.0	6.5	5,350	906	1.75	50	15	1,590	1,800	971	279	231	216	226	538	600	129	143		
Red (Picea rubens)	Coos County, N. H.	4	22.9	24	31	.396					3,440	5,820	1,143	.62	6.0								2,920		322				754	783				
White (Picea canadensis)	do	2	5.8	22	41	.318					3,160	5,200	968	.58	6.6								1,940		262				645	615				
Tamarack (Larix laricina)	Marathon and Shawano Counties, Wis.	5	19.9	38	52	.491	5.58	13.6	3.7	7.4	4,200	7,170	1,236	.84	7.2	30.0	7,750	1,263	2.67	50	28	3,010	3,480	1,596	480	401	380	370	883	843	167	159	236	274

NOTE.—The blank spaces in the table are due to the fact that some of the tests were made before the more comprehensive series at present under way was instituted.

.....	20.0	.....	69	.512	.....	....
5	19.0	.....	57	.546	.643	1
.....	22.0	.....	56	.577	.....	....
5	30.4	61	64	.590	.732	1
5	11.1	62	83	.569	.662	1
6	10.7	64	80	.568	.660	1
5	10.4	70	90	.565	.....	....
1	15.5	71	74	.637	.792	1
.....	.....	.....	88	.585	.....	....
5	22.1	65	58	.594	.704	1
5	15.6	60	62	.603	.696	1
5	16.0	67	78	.600	.708	1
5	12.5	71	77	.573	.669	1
.....	19.0	.....	80	.550	.....	....
1	6.5	82	31	.761	.838	
5	19.2	.....	81	.454	.526	1
1	15.9	26	121	.475	.545	1
5	23.4	36	55	.293	.315	
9	15.5	.....	80	.363	.....	....
4	24.8	38	79	.452	.513	1
5	15.0	14	47	.306	.321	
14	7.4	34	117	.383	.....	....
5	17.3	22	32	.418	.458	1
5	9.9	30	156	.350	.437	1
5	24.4	31	129	.340	.394	
5	20.1	17	44	.370	.415	1
5	30.3	14	58	.371	.407	1
5	16.5	37	63	.528	.599	1
5	22.1	41	54	.440	. 507	1
70	13.4	.....	52	.477	.....	....
5	11.9	34	123	.360	.386	
5	21.4	26	98	.353	.395	
5	13.0	31	125	.377	.433	1
5	31.9	20	93	.391	.435	
5	16.2	31	74	.363	.391	
.....	14.5	24	81	.334	.....	....
.....	24.4	32	69	.366	.....	....
5	17.1	16	45	.325	.359	1
5	11.3	13	156	.299	.335	1
4	22.9	24	31	.396	.....	....
2	5.8	22	41	.318	.....	....
5	19.9	38	52	.491	5.58	1

NOTE.—The blank spaces in the table are due to th

MECHANICAL PROPERTIES OF WOODS GROWN IN THE UNITED STATES.

THE TESTS.

The tests made by the Forest Service to determine the mechanical properties of woods grown in the United States fall into two classes: (1) Tests on full-sized pieces, such as bridge stringers and car sills, and (2) tests on small clear pieces free from defects. Tests of the first kind have been made on a number of species and the results presented in several publications. (See list on p. 4.) These results are of value in the formulation of grading rules for structural timber, in the establishment of working stresses, and in showing the influence of defects such as knots, shakes, and checks upon the strength of the material.

A series of tests of the second kind was begun by the Forest Service about two years ago to secure information that will enable the mechanical properties of the different woods to be compared, both in the green and air-dry state, and to determine the influence on strength of such factors as locality of growth, height of test pieces in the tree, and distance of pieces from pith. This preliminary circular gives in condensed form the average values thus far obtained from 49 species of wood tested in a green condition. More detailed analyses of the values will follow as the work progresses. The test material was cut from typical trees selected by members of the Forest Service, and records were made of the conditions of growth. Eventually each important species will be represented by averages from at least five typical trees from each of several localities throughout its range of growth. In several of the species listed in Table 1 averages are given from tests on less than five trees. Since there is considerable variation in the strength of wood from individual trees of the same species, such results should be taken as indications rather than as fixed values. The number of test pieces from each tree varied from 40 to 120, depending on the size of the tree. The total number of tests represented in Table 1 is about 25,000.

The tests, which comprise the series described above and others made previously, were made at laboratories of the Forest Service maintained in cooperation with the University of Wisconsin, Purdue University, University of Colorado, University of California, and University of Washington.

THE RESULTS.

Table 1 gives average values obtained from tests on green material 2 by 2 inches in cross section. The following kinds of tests were made: Bending, both static and impact; compression parallel and compression perpendicular to the grain; hardness; shear parallel to grain; cleavage or splitting; and tension at right angles to grain. The table also includes information on shrinkage, specific gravity, moisture content when tested, proportion of summerwood, and rate of growth or rings per radial inch.

LIST OF FOREST SERVICE PUBLICATIONS ON MECHANICAL AND PHYSICAL PROPERTIES OF WOOD.

BULLETINS.

Bul. 6. Timber Physics, Part I, Preliminary Report.[1]
8. Timber Physics, Part II, Progress Report.[1]
10. Timber—an Elementary Discussion of the Characteristics and Properties of Wood.[1]
13. Timber Pines of the Southern United States.
58. The Red Gum.
70. Effect of Moisture Upon the Strength and Stiffness of Wood.[1]
80. The Commercial Hickories.
88. Properties and Uses of Douglas Fir.
108. Tests of Structural Timbers.[1]
115. Mechanical Properties of Western Hemlock.
122. Mechanical Properties of Western Larch.

CIRCULARS.

Cir. 12. Southern Pine—Mechanical and Physical Properties.[1]
15. Summary of Mechanical Tests on Thirty-Two Species of American Woods.[1]
38. Instructions to Engineers of Timber Tests (Revised).
39. Experiments on the Strength of Treated Timber.
108. Strength of Wood as Influenced by Moisture.[1]
115. Second Progress Report on the Strength of Structural Timber.
142. Tests of Vehicle and Implement Woods.
164. Properties and Uses of Southern Pines.
179. Utilization of California Eucalypts.
189. Strength Values for Structural Timbers.[1]
193. Mechanical Properties of Redwood.

[1] Not available for free distribution, but can be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C.

ADDITIONAL COPIES of this publication may be procured from the SUPERINTENDENT OF DOCUMENTS, Government Printing Office, Washington, D. C., at 5 cents per copy